REMARKS

The Final Office Action mailed on October 25, 2005, has been reviewed and the comments of the Patent and Trademark Office have been considered. Prior to this paper, claims 1-47 were pending, with claims 9-11, 21-32, 34, 36, 38, 41-46 being withdrawn from prosecution. By this paper, Applicants cancel claim 47, and do not add any claims. Therefore, claims 1-46 remain pending.

The amendment to claim 13 merely places claim 47 into independent form, and thus does not change the scope of the claim set. Therefore, the amendment to claim 13 should be entered.

Applicants respectfully submit that the present application is in condition for allowance for at least the reasons that follow.

WO 98/37029 is not Prior Art

As a preliminary matter, Applicants note that WO 98/37029 is not prior art against the present application for at least the reason that this WO reference has an international filing date of February 18, 1998, and thus prior pending claim 47 (now claim 13) is allowable for at least this reason.

Applicants rely on MPEP §2136.03(II)(C), which states that if

> the international application has an international filing date prior to November 29, 2000, apply the refernce under the provisions of 35 USC 102 and 374, prior to the AIPA amendments: . . . (2) For U.S. application publications and WIPO publications directly resulting from international applications under PCT Article 21(2), ***never apply these references*** under 35 U.S.C. 102(e). These references may be applied as of their publication dates under 35 U.S.C. 102(a) or (b).

(Emphasis added.) Because the publication date of the WO reference is August 27, 1998, which is after the Belgian priority date of the present application of October 02, 1997, this reference is not prior art under §§102(a) / 102(b). Applicants respectfully submit that the

rejection of former claim 47 (now claim 13) has been traversed as a matter of law, and that current claim 13 is allowable for at least the reason that the rationale proffered in the Office Action to reject claim 47 is in error as a matter of law.

Acknowledgement of Priority Papers is Requested

In view of the use of WO 98/37029 as a reference against the present application, Applicant requests that an examiner obtain the priority papers from the International Bureau. The parent of this case (Application Serial Number 09/509,427) entered prosecution from PCT application PCT/EP98/06245. Applicant complied with PCT Rule 17(a)/(b), as evinced by the enclosed form PCT/DO/EO/903 (see Appendix A) in the parent application. An examiner should either review the file history of the parent application, or request that the International Bureau furnish a copy of the priority document to the PTO, and then acknowledge receipt of the priority papers for BE 9700792 (filed October 02, 1997) in this application.

Claims 1-12 Have Not Properly Been Examined

As a preliminary matter, Applicants again respectfully submit that the scope of claim 1 and the scope of claim 13 (prior to the above amendment) have incorrectly been treated as being the same. This is not the case. **Claim 1 utilizes the closed-ended phrase "consisting," with respect to the at least one layer, while claim 13 does not.** Specifically, claim 1 recites a burner "membrane comprising at least one layer **consisting** of a needled fiber web which has been compressed to a porosity of between 60% and 95%." (Emphasis added.) That is, one layer of the membrane is formed ***only*** by a needled fiber web compressed as claimed. In contrast, the proffered combinations result, assuming *arguendo*, in, at most, a ***sintered*** needled web. (As will be discussed in greater detail below, each and every example of a membrane in EP '146 is sintered.) Thus, the resulting web contains

additional binding features not recited in claim 1 and its dependencies, and, therefore, claim 1 is allowable for additional reasons.

The Office Action points to the use of the term "comprising" in claim 1 ***as it relates to the burner membrane***, and asserts that this renders the later use of "consisting of," with respect to the at least one layer, open ended. Applicants respectfully submit that this is contrary to the MPEP, as well as case law, and respectfully requests that the PTO identify where, at least in the MPEP, such claim analysis is supported. Simply put, while the claim leaves open additional elements to the burner membrane, it must have least one layer that ***only*** is made up of a needled fiber web as claimed.

Regarding the assertion that "sintering is a process," a sintered web is structure, just as a glued joint is structure, or a welded joint is structure, and thus would be recognized by the ordinary artisan as an element. Such analysis demonstrates the correctness of Applicants position. By analogy, just as a claim recitation reading "consisting of a welded joint" would not cover a welded joint that also includes a bolt through the joint, the claim recitation "consisting of a needled fiber web" would not include a needled fiber web that is also sintered.

Claim Rejections Under 35 U.S.C. § 103(a)

In the Office Action, claims 1-8, 12-20, 33, 35, 37, 39 and 40 stand rejected under 35 U.S.C. §103 as being obvious in view of EP 0628146 when combined with Krupnik et al. (U.S. Patent No. 6,298,538), while claims 35 and 37 stand rejected under the same statute in view of the combination of EP 0628146 with Krupnik and De Bruyne (U.S. Patent No. 5,088,919). Claim 47 stands rejected as obvious in view of the combination of EP '146 with Krupnik and WO 98/37029. A certified English translation of the Belgium priority application is attached.

* * * * *

As demonstrated above, WO 98/37029 is not prior art against the present application, and thus claim 47 (now claim 13) is allowable for at least this reason, along with claim 1, which, as noted above, utilizes the closed-ended format. Further, there are additional reasons why every pending claim is allowable, as will now be explained.

Applicants rely on MPEP § 2143, which states that:

> [t]o establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.

It is respectfully submitted that the Office Action has not met any of the first, second and the third criteria of MPEP § 2143.

Lack of Suggestion to Modify the Reference

MPEP § 2143.01, entitled *Suggestion or Motivation to Modify the References*, states that the "prior art *must* suggest the desirability of the claimed invention." (emphasis added; citations omitted) It further states that obviousness

> can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either explicitly or implicitly in the references themselves or in the knowledge generally available to one of ordinary skill in the art. 'The test for an implicit showing is what the combined teachings, knowledge of one of ordinary skill in the art, and the nature of the problem to be solved as a whole would have suggested to those of ordinary skill in the art.'

(Citations omitted.)

It would not have been obvious to combine EP '146 with Krupnik, as is alleged in the Office Action. The skilled artisan would have perceived that the combination of EP '146 with Krupnik would not result in a web having a porosity in the range alleged in the Office Action (78% to 88%), at least ***without sintering***. In fact, the skilled artisan would have considered the sintering operation of EP '146 to be essential in achieving the porosity range identified in the Office Action. Thus, there would have been no motivation to produce a membrane that did not include a sintered web.

The Office Action relies on the disclosure in EP '146 of a burner membrane web having a porosity of 78%-88% which is sintered. In this regard, all teachings in EP '146 are directed to a sintered web, including every example disclosed therein. Indeed, so important is the sintering operation in EP '146 that each claim includes this limitation. EP '146 clearly directs the reader to utilize sintering.

Even without the great emphasis that EP '146 places on sintering (*i.e.,* assuming *arguendo* that artisans would have been able to take the innovative step and ignore the emphasis on sintering), the skilled artisan would still have understood that the webs of EP '146 would necessarily be sintered to achieve this porosity. This is because it has long been known that mere compression of metal fiber webs results in a product of very low density, translating to a high porosity. That is, without the sintering step taught in EP '416, the skilled artisan would have recognized the teachings of EP '416 to not result in a web with the porosity detailed therein. As evidence of this, Applicants point to Patent No. 1,904,026, (provided in Appendix B), which teaches that a metal fiber web expands its thickness after compression to about 0.0135 pounds per cubic inch (page 2, lines 121-131), translating to a density of about 4.6% of the specific weight of steel (the specific weight of steel being about 8 grams per cubic centimeter). 4.6% density translates to a porosity of about 95.4% (100% - 4.6%). Thus, the skilled artisan versed in burner membranes would have accepted that without sintering, the porosity taught by the EP '146 reference ***could not*** be achieved (and hence the great emphasis that EP '146 places on sintering).

Because the skilled artisan would have viewed as fact, based on the prior art (to which he is assumed to be completely aware under the law) that the porosities of EP '146 (78% to

88%) could not be achieved without sintering, the skilled artisan would not have attempted to eliminate sintering to practice EP '146, and thus would not have arrived at the invention as claimed, which ***excludes sintering***.

The teachings of Krupnick with respect to needling do not alleviate the need to sinter the web of EP '146 to achieve a porosity of 78% to 88% relied on in the Office Action. The skilled artisan would have known that the needle punching of Krupnick would not have resulted in the asserted porosity. Again, such evidence is found in the prior art. For example, the textbook *Non-Woven Bonded Fabrics*, by Ellis Horwood Ltd, published in 1985 (excerpts of which are provided in Appendix C), pages 204-205, teaches a polyamide fiber (PA) non-woven needled web. (Note that Krupnick's states that his teachings are also applicable to polymeric fibers – see Col. 4, lines 1-5.) *Non-woven Bonded Fabrics* teaches that the density range of the web, as tested, was between 0.05 and 0.10 grams per cubic centimeter. In view of the fact that the specific weight of polyamide ranges from about 1.02 to 1.13 grams per cubic centimeter, as evinced by the website Terka: "Tek Tip – Density vs. Specific Gravity" (see appendix D), the density of the tested webs is thus, at its maximum, 9.8%, which is achieved by using the polyamide with the lowest specific weight. Accordingly, the skilled artisan would have recognized that needling a fiber web results in, at best, a porosity of about 90% or more, and thus the skilled artisan would not have recognized needling as meeting the porosity requirements of EP '146 (78%-88%). The skilled artisan thus would have had no motivation to eliminate sintering in favor of needling.

In sum, the skilled artisan, accepting that sintering was essential in EP '146 to achieving the porosity asserted in the Office Action, as evinced by the prior art, would not have been motivated to eliminate sintering to arrive at the present invention. Indeed, by this measure, ***the prior art teaches away from such modification***, as the skilled artisan would have been discouraged from eliminating sintering. MPEP § 2144.05(III), entitled Rebuttal Of *Prima Facie* Case Of Obviousness, states that a "*prima facie* case of obviousness may also be rebutted by showing that the art, in ***any*** material respect, teaches away from the claimed invention." (MPEP § 2144.05(III), second paragraph, emphasis added, citations omitted.) Thus, to the extent that a *prima facie* case of obviousness has been made, such case is hereby rebutted.

Moreover, EP '146 also teaches away from combination with Krupnik. EP '146 teaches a plate made from a *sintered* metal fiber web. *Each and every* example provided in EP '146 of a burner membrane is explicitly sintered, and, as noted above, such would have been seen as critical by the skilled artisan. Further, *each and every* example provides that the porosity of EP '146 is achieved by compression *and* sintering. That is, there is nothing in the reference that suggests the teachings of the reference can be used with a binding method other than sintering. Indeed, one would not need to needle the fiber web, as the fiber web would be bound by the sintering step. That is, the sintering step would completely defeat the purpose of needling the web, and a skilled artisan would not be motivated to do such a thing. Accordingly, EP '146 teaches away from utilizing needling.

* * * * *

Sintering issues aside, Applicants again respectfully submit that the Krupnik reference teaches away incorporating Krupnik into a burner membrane by teaching that it is important that the fibers retain the oil on their outer surfaces.[1] The Office Action discounts this argument, alleging that (1) a "recitation of intended use of the claimed invention must result in a structural difference," and that (2) "EP '146 itself teaches a burner membrane and that Krupnik is relied on for the teaching of needling." First, the recitation of a "burner membrane" in the claims is structure, structure recognizable by the skilled artisan, and thus is not merely "intended use." Second, the issue of intended use of the claimed invention is irrelevant to Krupnik teaching away from ***combination with EP '416***, which teaches a burner membrane. ***That is, the ordinary artisan would have been discouraged from utilizing the oil laced fibers of Krupnik in the burner membrane web of EP '146.*** Applicants

[1] Krupnik prominently teaches that it is important that the fibers retain the oil on their outer surfaces from the shaving process, and that, if the oil is not retained, oil can be added directly to the mass of loose fibers after the shaving process. (Column 3, lines 8-15.) It is well known in the art that the presence of oil or other organic material on a burner membrane can cause early rupture of the membrane due to carbon precipitation. Carbon atoms from the burned organic material enter into the molecular structure of the alloy, and locally change the alloy balance. Usually, the carbon precipitation makes the alloy less resistant to oxidation under higher temperatures. Thus, one of ordinary skill in the art seeking a burner membrane would not seek to combine Krupnik with the other references. (It is noted that the presence of organic material is difficult if not impossible to eliminate in the art, and the presence of some organic material in or on the burner membrane is expected. Applicants simply note that one of ordinary skill in the art would not find motivation use the teachings of Krupnik in combination with the other references due to the importance that Krupnik places on oil retention.) Again, to the extent that a *prima facie* case of obviousness has been made, that case is hereby rebutted.

respectfully submit that if the PTO maintains a rejection of the claims based on the combination of Krupnik with EP '146, that the PTO specifically identify why it believes that this is not the case.

Applicants remind the PTO that a reference is used for all that it teaches, and in this instance, Krupnik teaches only embodiments that are lubricated with oil. This teaching cannot be ignored by the PTO, as this teaching would have discouraged the ordinary artisan from looking to Krupnik to modify the burner membrane of EP '146.

* * * * *

Furthermore, the proposed modification would change the principle of operation of EP '146. The Office Action discounts this argument by stating that "there is nothing on the record to show that needling the EP '146 web would change the principle of operation of EP '146. Needling would make the web stronger." First, applicants placed such showing in the record by pointing out in the Response filed on August 16, 2005 that the principle of operation of EP '146 is to provide a porous metal fiber plate that is bound together by the fusion of the molecules of the metal (*i.e.* sintering), and that, in contrast, the fiber web as claimed is bound together by the commingling of the fibers (*i.e.* needling). Second, regarding the statement that "needling would make the web stronger," such statement still does not cure a change in the principle of operation with respect to obviousness. The MPEP makes clear that it would not be obvious to modify the references if such modification results in a change in the principle of operation. That is, regardless of the advantages that flow from such modification, the change in the principle of operation renders the modification nonobvious.

Moreover, no evidence has been presented that needling a sintered web makes such a web stronger, at it is probable that needling weakens the bonds. Applicants submit that Official Notice is being used according to MPEP § 2144.03, to satisfy the first requirement of MPEP § 2143, Applicants remind the PTO that § 2144.03 allows an applicant "to traverse such an assertion," and that when an applicant does so, "the examiner should cite a reference in support of his or her position." (MPEP § 2144.03, second paragraph.) Absent a citation by the PTO of a reference that can be evaluated for all its teachings, Applicants hereby traverse

the assertion that needling would make a sintered web stronger. **Applicants thus request that the examiner cite a reference in support of the position taken in the Office Action, else allow the claims.**

* * * * *

Still further, the combination of the references to achieve the given results would not have been obvious for additional reasons. To achieve the results of the claims using the knowledge taught by the references, a person of ordinary skill must first ignore the prominent teachings of EP '146 regarding sintering, and then add the step of needling to EP '146. Applicants submit that such an action would not result from the labor of an ordinary skilled artisan, but from the diligent work of an innovator. Since a reference has not been provided that teaches needling as a suitable, nondetrimental substitute to sintering in the burner membrane arts, it is not reasonable to presume that the limitations of the claims would have been obvious to one of ordinary skill in the art knowing the teachings of the cited references.

Lack of a Reasonable Expectation of Success

MPEP § 2143.02 permits references to be modified or combined to reject a claim as obvious only if there is a reasonable expectation of success. There is no evidence in the references, and certainly none identified in the Office Action, that one of ordinary skill in the art would have a reasonable expectation of success in achieving Applicants' invention by combining the references. For example, the references are silent in regard to a teaching that a compressed needled web has the same properties as a sintered web in regard to a web for a burner membrane. Indeed, Applicants have placed into the record that such would not have been expected by the skilled artisan. (Applicants note that this example is simply a starting point for a showing of a reasonable expectation of success; more would be needed.) Thus, one of ordinary skill in the art would not see the combination of the references as producing a successful burner membrane. Because of this, the second criteria of MPEP § 2143 has not been met in the Office Action, and a *prima facie* case of obviousness has therefore not been established.

The References Do Not Suggest All Claim Recitations

As noted above, the pending claims recite that at least one layer must not include a sintered body. This recitation is not met by the membrane resulting from the combinations proffered in the Office Action for the reasons detailed above.

Moreover, independent claims 1 and 13 both recite a burner membrane comprising "a **needled** fiber web which is **compressed** to a porosity of between 60% and 95% . . . wherein the fiber web is needled in one step and compressed in a different step." (Emphasis added.) That is, the needling occurs ***before*** the compression step, else the "**needled** fiber web" could not be compressed. Moreover, the compression of the **needled** fiber web results in the claimed porosity.

The Office Action asserts that EP '146 teaches "a compressed **web** of stainless steel fibers. The **web** having a porosity of about 78-88 percent," and recognizes that EP '146 does not teach needling. (Emphasis added.) The Office Action relies on Krupnik to remedy this deficiency, asserting that "it would have been obvious . . . to have needled the **web** of EP '146, in order to produce a stronger fabric." (Emphasis added.) However, even if Krupnik's needling were utilized on the web of EP '416, the above features of the claims under consideration would still not be achieved. First, needling the web would thus result in needling after compression – not before compression, as is required by the claims. Second, it is not clear that needling the membrane of EP '416, either *before or after* compression, would result in a membrane having the claimed porosity, and no evidence has been proffered to the contrary. That is, needling will skew the porosity away from the ranges taught in EP '416, and thus away from the claimed ranges. (This is even more so in the case of claim 2, which teaches a narrower porosity range.)

Conversely, Applicants' claims are directed towards a *needled* fiber web that is compressed a certain amount so that the needled fiber web achieves a desired porosity. This is not found in the cited references. Applicants submit that the process of needling alters the porosity of the material, just as compression alters the porosity of the material, and thus

needling the web as proffered in the Office Action changes the porosity of the material from the ranges cited in the Office Action. Thus, another recitation is not present even after combination.

* * * * *

To arrive at the recitations regarding the weight of the fiber web in many of the rejected dependent claims, the Office Action asserts that routine experimentation would be used. Applicants previously traversed this assertion, pointing out that no evidence has been proffered to support such assertions, that traversal being incorporated herein by reference.

In response, the Office Action states that "it is the examiner's position that a material having a low basis weight would generally be strong[er] than a material having a greater basis weight, all other elements of the web being equal." First, a "position" is not evidence. Second, it appears that Official notice is again being used according to MPEP § 2144.03. Applicants remind the PTO that § 2144.03 allows an applicant "to traverse such an assertion," and that when an applicant does so, "the examiner should cite a reference in support of his or her position." (MPEP § 2144.03, second paragraph.) Absent a citation by the PTO of a reference that can be evaluated for all its teachings, Applicants hereby traverse "the examiner's position." **Applicants thus request that the examiner cite a reference in support of the position taken in the Office Action, else allow the claims.**

* * * * *

In sum, the proffered combination fails to meet the third requirement of MPEP § 2143 for at least three reasons, and thus independent claims 1 and 13 are allowable, along with the claims that depend therefrom. This is also the case with claims 35 and 37, at least because De Bruyne does not remedy the above identified deficiencies with EP '146 and Krupnik.

Request for Rejoinder of Withdrawn Claims

Claims 9-11, 21-32, 34, 36, 38, 41-46 stand withdrawn. These claims are *method claims drawn to a method of making an apparatus along the lines of the considered claims.* Pursuant to MPEP § 821.04 and *In re Ochiai*, 71 F.3d 1565, 37 USPQ2d 1127 (Fed. Cir. 1995), it is respectfully requested that these claims be rejoined and considered, since MPEP § 821.04 states that "when a product claim is found allowable, applicant may present claims directed to the process of making and/or using the patentable product."

In view of the above, Applicants note that of the withdrawn claims, claims 9, 21, 27, 33, 34 and 41-46 ultimately depend from claims 1 or 13. Applicants respectfully request that these claims be rejoined and allowed at least due to their dependency from claims 1 and 13, claims that are allowable.

As to the remaining claims, Applicants submit that these claims are allowable for at least the reasons that make the claims under consideration allowable. Applicants respectfully submit that no significant burden is placed on the PTO by rejoining and examining all the withdrawn claims. Indeed, many of the withdrawn claims explicitly recite recitations consistent with the above arguments. (For example, claims 10 and 22 affirmatively recite that the membrane is not sintered.)

Conclusion

Applicants believe that the present application is in condition for allowance, and favorable reconsideration is requested.

If Applicants have not accounted for any fees required by this Amendment, the Commissioner is hereby authorized to charge to our Deposit Account No. 19-0741. If Applicants have not accounted for a required extension of time under 37 C.F.R. § 1.136, that extension is requested and the corresponding fee should be charged to our Deposit Account.

Examiner Cole is invited to contact the undersigned by telephone if it is felt that a telephone interview would advance the prosecution of the present application.

Respectfully submitted,

Date July 25, 2006

By

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APPENDIX A

UNITED STATES PATENT AND TRADEMARK OFFICE CORRECTED 903

Commissioner for Patents, Box PCT
United States Patent and Trademark Office
Washington, D.C. 20231
www.uspto.gov

U.S. APPLICATION NO.		FIRST NAMED APPLICANT	ATTY. DOCKET NO.
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INTERNATIONAL APPLICATION NO.
PCT/EP98/06245

I.A. FILING DATE	PRIORITY DATE
29 SEP 98	02 OCT 97

GLENN LAW
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WASHINGTON HARBOUR
3000 K STREET NW SUITE 500
WASHINGTON, DC 20007 5109

DATE MAILED: 10 AUG 2001

NOTIFICATION OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C. 371 AND 37 CFR 1.494 OR 1.495

1. The applicant is hereby advised that the United States Patent and Trademark Office in its capacity as ☐ a Designated Office (37 CFR 1.494), ☒ an Elected Office (37 CFR 1.495), has determined that the above-identified international application has met the requirements of 35 U.S.C. 371, and is **ACCEPTED** for national patentability examination in the United States Patent and Trademark Office.

2. The United States Application Number assigned to the application is shown above and the relevant dates are:

28 March 2000	28 March 2000
DATE OF RECEIPT OF 35 U.S.C. 371(c)(1), (c)(2) and (c)(4) REQUIREMENTS	DATE OF RECEIPT OF ALL 35 U.S.C. 371 REQUIREMENTS

A Filing Receipt (PTO-103X) will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE "FILING DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN ABOVE.** *The filing date of the above-identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363).* Once the Filing Receipt has been received, send all correspondence to the Group Art Unit designated thereon.

3. ☐ A request for immediate examination under 35 U.S.C. 371(f) was received on _____ and the application will be examined in turn.

4. The following items have been received:
- ☒ U.S. Basic National Fee.
- ☒ Copy of the international application.
- ☐ Translation of the international application into English.
- ☒ Oath or Declaration of inventors(s).
- ☐ Copy of Article 19 amendments. ☐ Translation of Article 19 amendments into English.
  The Article 19 amendments ☐ have ☐ not been entered.
- ☒ The International Preliminary Examination Report in English and its Annexes, if any.
- ☐ Copy of the Annexes to the International Preliminary Examination Report (IPER).
  ☐ Translation of Annexes to the IPER into English.
  The Annexes ☐ have ☐ not been entered.
- ☒ Preliminary amendment(s) filed 28 March 2000 and _____
- ☒ Information Disclosure Statement(s) filed 26 June 2000 and _____.
- ☒ Assignment document.
- ☐ Power of Attorney and/or Change of Address.
- ☐ Substitute specification filed _____.
- ☐ Indication of Small Entity Status.
- ☒ Priority Document.
- ☒ Copy of the International Search Report ☒ and copies of the references cited therein.
- ☒ Other: 337

Applicant is reminded that any communication to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5).

Kaya Baltimore
Telephone: 703-305-3695

FORM PCT/DO/EO/903 (March 2001)

PTO ACK'd Receipt of Priority does on 12/18/02 IN parent File.

KINGDOM OF BELGIUM

It is declared herewith that the appended documents are true copies of the documents joined to the application for patent, such as they were filed in Belgium according to the appended certificate of filing.

Brussels, -1-10-1998
For the Director of the Department of
Commercial and Industrial Property

The empowered Officer,

(signature unreadable)
BAILLEUX G.
Adjunct-Advisor

Ministry of Economic Affairs

Department of Industrial Property

FILING RECORD
FOR A PATENT APPLICATION
No. 09700792

Today -2-10-1997 an envelope forwarded by post has been received with the Department of Industrial Property concerning an application for a patent of invention concerning : BURNER MEMBRANE COMPRISING A NEEDLED METAL FIBRE WEB.

filed by : LEO RYCKEBOER

acting for : N.V. BEKAERT S.A.
Bekaertstraat 2
B 8550 ZWEVEGEM - Belgium

as authorized representative of the applicant.

The receipt of aforementioned patent application has been taken note of at 10 o'clock a.m.

The application as filed comprises the documents required to obtain a filing date according to article 16 § 1 of the law of March 28, 1984.

The authorized Official,

(signature unreadable)

Brussels, -2-10-1997

SCHIETTECATTE W.
Adjunct-Advisor

BURNER MEMBRANE COMPRISING A NEEDLED METAL FIBRE WEB

The invention relates to a burner membrane comprising heat-resistant stainless steel fibres.

A number of types of burner membranes composed of heat-resistant stainless steel fibres are already known, comprising, for example, a sintered metal fibre web or a knitted metal fibre structure.

However, the use of a sintered web as a burner membrane, as described in European patent EP 0157432, displays a few drawbacks. For example, the porosity of a sintered metal fibre web as such is often insufficiently homogeneous, so that the flow of gas through the membrane is not sufficiently uniform. The axial temperature gradient that is established through the burner membrane during burning results in a non-homogeneous thermal expansion and mechanical [stresses]. After a number of heating and cooling cycles, these stresses can lead to cracks or fissures in the membrane. These drawbacks can in part be dealt with by providing the surface of the burner membrane with a regular pattern of perforations or a grid-like pattern of grooves, such as described respectively in PCT patent application WO 93/18342 and European patent EP 0390255, both submitted by the applicant. Furthermore, a burner membrane composed of a sintered metal fibre web is deformable only to a limited extent, which also constitutes a significant drawback.

Knitted membranes composed of metal fibres, as described in PCT patent application WO 97/04152 of the applicant, deal to a significant extent with the aforementioned drawbacks, but their construction is relatively complicated.

It is the object of the invention to deal with the drawbacks of the aforementioned types of burner membranes and to provide a metal fibre burner membrane that possesses a high and nearly homogeneous porosity, and that is to a large extent deformable. Moreover, the membrane possesses a considerable mechanical cohesion and strength, and can be fabricated in a inexpensive and simple manner.

To this end, the invention provides a burner membrane comprising at least one layer consisting of a compressed, needled fibre web composed of heat-resistant stainless steel fibres. The porosity of the burner membrane is between 60 and 95%.

The heat-resistant stainless steel fibre bundles that are incorporated in the fibre web and that are composed, for example, of Fecralloy®, can be obtained by means of the technique of bundled drawing, as described in US patent 3379000, or by shaving the rolled edge of a roll of metal foil, as described in US patent 4930199, or directly from the melt, for example by extrusion, as described in US patent 5524704.

The steel fibres have an equivalent diameter of between 5 and 150 µm, by preference between 10 and 50 µm. The equivalent diameter is here defined as the diameter of an imaginary round fibre having the same cross-section as that of the real fibre in question.

Apart from this, steel wool can also be used to fabricate the fibre web.

The burner membrane according to the invention can be obtained by:

a) providing a fibre web composed of heat-resistant stainless steel fibres, whether multi-layered or not;
b) needling the fibre web;
c) compressing the needled fibre web to the desired porosity, for example by means of a roller or press operation.

A correspondingly formed burner membrane can be obtained by needling a flat, tubular, cylindrical or conical metal fibre web.

The burner membrane according to the invention has a nearly homogeneous porosity, which is between 60 and 95%, and by preference between 80 and 95%. This makes it possible to utilize large and uniform gas flows.

The weight of the burner membrane is between 400 and 4000 g/m², and is by preference between 1000 and 2500 g/m².

In the needled felt thus obtained, the metal fibres are intertwined with one another, a fact which lends considerable mechanical cohesion and strength, yet does not impair the good deformability of the needled felt.

Moreover, the thermal expansion of the burner membrane can take place unhindered, and there is nearly no danger of cracks or fissures appearing.

In order to improve the homogeneity of the gas flow even further, the burner membrane can be perforated in a regular pattern over at least a portion of its surface, for example by mechanical means or with the aid of laser techniques.

The web formation, needling, compressing and in some cases perforating can be carried out consecutively on a single production line, which makes the manufacture of the burner membrane relatively simple and inexpensive.

The burner membrane according to the invention can also be coated with substances that activate the oxidation of the fuel mixture.

In an alternative embodiment, the needled metal fibre web, whether

multilayered or not, can be pressed in a cold isostatic manner such that a smooth surface is obtained on either one or both sides of the web. The principle of cold isostatic pressing is described in European patent EP 0329863 of the applicant.

Furthermore, in addition to a needled fibre web, another metal fibre network, such as a woven or knitted fabric, can also be incorporated into the burner membrane according to the invention.

Example

A burner membrane according to the invention has been manufactured out of Fecralloy® heat-resistant stainless steel fibres having an equivalent diameter of 35 µm. Four metal fibre webs were stacked on top of one another and needled to form a multilayered needled felt with a weight of 1580 g/m². This needled felt was placed between two stainless steel plates and rolled at a pressure of 200 bar to form a membrane with a thickness of 1.5 mm and a nearly homogeneous porosity of 85.7%.

The (flat) burner membrane thus obtained was used as a part of a surface burner for gas, and was tested in a radiation system and a blue-flame system at heat fluxes of 100 to 5000 kW/m².

The high, homogeneous porosity of the burner membrane results in a very homogeneous combustion and enables the use of large gas flows.

In addition, the burner membrane has good deformability and substantial mechanical sturdiness.

Moreover, as a result of the very open structure of the burner membrane, no filter is required for the gas mixture which is to be burned.

The chance of flame resonance is very small, so that, among other

things, the disturbance of whistling sounds is avoided.

Furthermore, the burner membrane according to the invention offers good resistance to flashback, both with sub- and super-stoichiometric combustion of (for example) methane, ethane, propane and butane, or of gases containing hydrogen and/or carbon monoxide.

Moreover, the burner membrane according to the invention offers the advantage that the required time span for warming up or cooling off is extremely short, so that a very great variation in heat flux can be realized in a very short time (order of magnitude of seconds). Hence the changeover from one combustion system to another occurs very smoothly and the cooling off time is very short. This quick response is very advantageous from the point of view of safety.

Claims

1 Burner membrane comprising at least one layer consisting of a compressed needled fibre web with a porosity of between 60 and 95%, and that is constructed of heat-resistant stainless steel fibres.

2 Burner membrane according to Claim 1, in which the porosity of the needled fibre web is between 80 and 95%.

3 Burner membrane according to Claim 1, in which the fibre web consists of steel fibres having an equivalent diameter of between 5 and 150 µm.

4 Burner membrane according to Claim 3, in which the fibre web consists of steel fibres having an equivalent diameter of between 10 and 50 µm.

5 Burner membrane according to Claim 1, in which the weight of the fibre web is between 400 and 4000 g/m².

6 Burner membrane according to Claim 5, in which the weight of the fibre web is between 1000 and 2500 g/m².

7 Burner membrane according to Claim 1, which is provided with a regular pattern of perforations over at least a portion of its surface.

8 Method for manufacturing a burner membrane according to Claim 1 comprising the following steps:

(a) providing a fibre web composed of metal fibres;

(b) needling the fibre web;

(c) compressing the needled fibre web to the desired porosity.

9 Use of a burner membrane according to Claims 1 or 7 as part of a surface burner for gas.

APPENDIX B

April 18, 1933. C. FIELD ET AL 1,904,026

MANUFACTURE OF RESILIENT PADS

Filed June 12, 1929

Fig. 1.

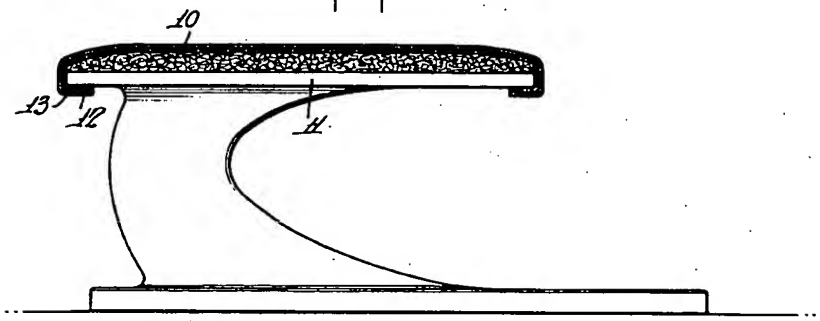


Fig. 2.

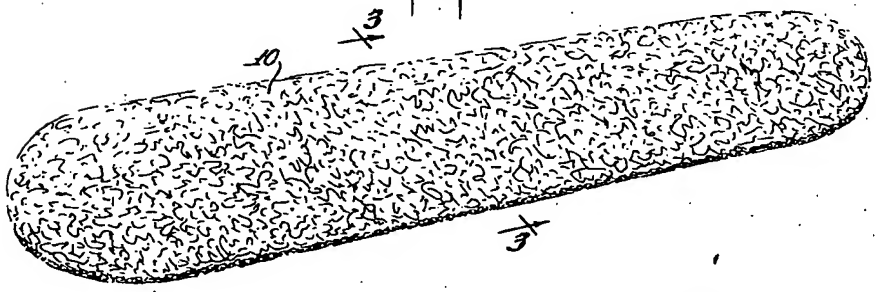


Fig. 3.

Fig. 4.

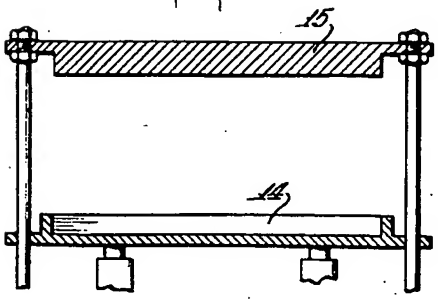
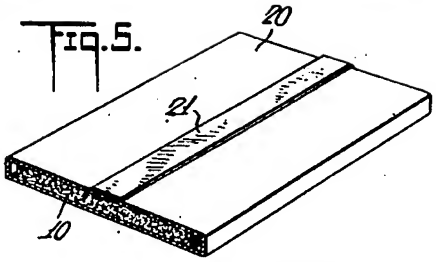


Fig. 5.



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Patented Apr. 18, 1933 1,904,026

UNITED STATES PATENT OFFICE

CROSBY FIELD, OF BROOKLYN, AND CLINTON L. CAMPBELL, OF SCARSDALE, NEW YORK, ASSIGNORS TO BRILLO MANUFACTURING COMPANY, INC., A CORPORATION OF NEW YORK

MANUFACTURE OF RESILIENT PADS

Application filed June 12, 1929. Serial No. 370,918.

The present invention is concerned with resilient pads which though preferably made from ordinary commercial grades of steel wool, have the approximately constant compression and resilience characteristics throughout long periods of use; with methods of producing them, and with packaging the pads for purposes of storage and shipment. The pads or mats are capable of a varied field of utility where relatively constant resilience under long repeated compressions is necessary for commercial success, but are especially adapted for embodiment in laundry or clothes press pads to supplement or replace the conventional spring cushions and other fibrous materials which are now commonly employed on the press bucks.

Objects of the invention are to provide a pad of this type which will be of uniform and enduring resiliency when subjected to often repeated, relatively high compressions; which will not develop rust in storage, and which when in use will effectively safeguard against breaking the most delicate buttons or injuring the finest fabrics which may be ironed by the press.

The resilient quality of steel wool is well known but no one has thus far succeeded in controlling this quality so as to make the pads sufficiently standardized and enduring for the particular purpose with which the present invention concerns itself. Our invention is based on the discovery that this is because no prior pads, whether for abrasive or for cushioning purposes, have been given initial compression substantially greater than the pressures which they are subjected to in use, and in most of them, the initial compression is not in the same direction as the use pressure. Consequently, where the use requires repeated relatively heavy pressures as in the laundry or clothes presses of the prior art, each pressure and release operates to bend a certain number of the fibers beyond the limit of elastic resilience, thereby giving more and more of them a permanent set, the result being that in a relatively short period of use, sometimes only a few months and sometimes only a few weeks, the thickness of the pad has been reduced to that of a mere sheet, and the range of resilience is so reduced as to render the pad inoperative for purposes above described, such as avoiding buttons or injury of fine fabrics. We have further discovered that the steel wool pads or mats can be rendered uniformly and enduringly resilient throughout a desired range of spring movement, and that this may be accomplished by making the initial pad of relatively great thickness and subjecting it to an initial pressure that is relatively enormous as compared with the ordinary pressures or stresses to which it is subjected in use. Thus, the initial set of the fibers of the pad so far exceeds that producible by use pressures, that the pad becomes dependable as to constant thickness and range of resilience.

We utilize this discovery by producing a pad or mat of wool which has been subjected to a comparatively high pressure in a forming die, the pressure being sufficient to impart to the steel wool mass a definite and substantially permanent contour. These pressures are in general far greater than is ever applied to steel wool scouring pads used for abrasive purposes and, in fact, are such as to render the fibers extremely stiff and far too brittle and too easily broken by pressures edgewise to the initial set, such as are always applied in ordinary use of scouring pads. Tests with these unprecedented pressures have demonstrated that there are limits of high forming pressure which must not be exceeded, for otherwise the mass will be permanently reduced to undesirable stiffness and hardness, flatwise as well as edgewise, and will not have a range of spring action such as is required for a spring cushion pad. In this connection it may be noted that the very delicate and relatively minute steel wool fibers, when bundled or bunched into a matted mass of interlaced intercurled fibrous material, will produce a mat having an astonishingly high elastic range and capable of withstanding compression in the order of a third of a ton or more per square inch without destruction of its resiliency.

In practice when forming a pad we spread the desired quantity of steel wool of fairly coarse grade, evenly on a table or in a die of

the proper size and shape and subject the mass to a compression which flattens it out into almost sheet like form. The mass has little tendency to lateral expansion even if laterally unrestrained. When the pressure is relieved the pad quickly springs back to a substantial thickness which for the preferred sizes of fiber and thickness of pad will not exceed three times the initial compression thickness of the sheet, so that in its expanded condition the resulting spring pad is of very substantial density.

If this pad is held in place on a press buck by the usual inner covering of flannel and tautly stretched outer covering of cotton fabric it will have no tendency to further expand in thickness and will as above suggested be of uniform resiliency in all directions under all ordinary pressures to which it may be subjected in the press, these pressures during use being commonly quite low as compared to the forming pressure initially applied on the pad, say about seven pounds per square inch.

In cases where the pads are to be stored for comparatively long periods of time before application to a press buck they will have a tendency to gradually increase in thickness. This tendency we overcome by packaging the pads in a shallow box which is of slightly less depth than the normal thickness of the pads and which holds the pads under slight compression during storage.

The pads, when on the press, are subjected to the usual high press temperatures which preclude the presence of moisture, and are furthermore enclosed by the flannel which substantially excludes air so that they have little or no tendency to oxidize or rust. During storage, however, and during manufacture the formation of rust or incipient rust must be guarded against. This we preferably accomplish by cutting the wool in the presence of a compound which completely coats it with a very thin paraffin film. Ordinary methods of cutting with oil are avoided to prevent the mass from developing undue greasiness under subsequent compression. Dry cutting methods are not satisfactory because they slow down the cutting process and wear out the cutting knives and do not prevent rust during storage.

When the pads are put in use the intense heat of the press quickly burns out some of the constituent elements of the paraffin which as above explained has primarily the function of preventing the formation of incipient rust during manufacture and storage of the pads, the residue of the paraffin forming a permanent black protective coating on the individual fibers of the steel wool, so that there is little or no tendency for them to rust in use.

The invention may be more fully understood from the following description in connection with the accompanying drawing, wherein

Fig. 1 is a sectional view showing one of the pads in place on a press buck;

Fig. 2 is a perspective view of the pad;

Fig. 3 is a transverse sectional view therethrough;

Fig. 4 is a diagrammatic sectional view of the forming press; and

Fig. 5 is a sectional view of the package.

The finished pad 10 as seen in Figs. 2 and 3 is about five-eighths of an inch thick and is held in place on the press buck 11 by the conventional inner layer of flannel 12 and the outer layer 13 of light cotton fabric.

An important feature of a steel wool pad formed in accordance with the present invention is that, due to its ready flexibility it may, if oversized, be folded around the edges of the press buck.

The means for holding these fabric layers tautly stretched so as not to wrinkle the goods being pressed and incidentally to hold the steel wool pad under slight compression are not in themselves our invention, may be entirely conventional and are therefore not shown.

We preferably use steel wool that has been made on the Field type of machine with special machinery described in the co-pending application of one of the inventors, Ser. No. 276,317, for "conveyor and storage apparatus for metal wool machines", filed August 3rd, 1928. The invention described therein indicates a method of obtaining the wool in a loose fibrous tangled mass of rather fluffy constituency. We do not, of course, limit our invention to wool made in this fashion, but such wool has been found preferable.

About three pounds of this fluff is gathered up, slightly compacted by hand and spread evenly in the female element 14 of the forming die mounted for instance on the plunger of a hydraulic press. In a particular case the three pounds of wool filled the female die to a depth of about six inches. Wool filled element 14 is then moved upwardly by the plunger into coaction with the male element 15 of the die and the material subjected to a pressure in the order of one hundred tons for a spring pad of about 300 square inches area or about 650 to 700 pounds per square inch which flattens the mass out into a very thin sheet, no clearance in fact being provided between the working faces of the members 14 and 15. When the pressure is relieved the flattened mat quickly expands to a thickness two to four times the minimum thickness under the forming pressure, dependent on the size of the fibers, and in a given case, the expanded thickness may be about five-eighths of an inch at which time its density is around 0.0135 pounds per cubic inch. It will be noted that in the above illustrative case where the forming pressure of

the pad is, say, 600 to 700 pounds per square inch, said pressure is approximately 100 times ordinary pressure applied by the buck in a laundry or clothes pressing machine. While this is by no means the lower limit of forming pressure that will give a useful density, it is to be noted that in all cases my invention requires that the initial forming pressure be vastly greater than the use pressures so that the pad will stand up under continued use pressure for long periods of time, that is, a year or years, as contrasted with a limit of a very few weeks or months, characteristic of steel wool pads which have not been given such initial forming pressure.

We have thus far been unable to find accurate limits for the effective compression range and density range although we have discovered that exceedingly high pressures, say around 850 tons or, say, 5,000 pounds per square inch, flatten and apparently weld the individual fibers of the mass together, completely killing all resiliency; also that pressures of less than fifty tons or 333 pounds per square inch do not give the desired "set" or more or less permanent form desired.

The pressures are subject to change in any event where larger charges of wool are used for a given area of die or where wool of other grades is used.

To prevent further expansion of the mat during storage and shipment we package them under slight compression in shallow boxes 20 of fiber board or corrugated paper board closed by the usual taped paper strips 21.

The pads embodying the invention and produced by our method may have various uses other than the specific one discussed herein. They are particularly suited for instance for use as floor mats under rugs and carpets.

With provisions such as those described above we have found that coarse wool commonly known as No. 3 grade gives the best results, although finer grade material might be used when the pressures of manufacture are not so high.

When used for laundry or clothes press purposes, the mats may either entirely replace the usual spring pads or may serve to supplement them. When used on presses which pass live steam through the fabric being pressed, it will be obvious that the wool should be effectively permanently rust-proofed.

We claim:

1. A method of making resilient pads of metal wool which includes subjecting a loose matted mass of wool in forming dies to a pressure in excess of one sixth of a ton per square inch, the quantity of wool being such that the wool is flattened out into a thin sheet under the dies and expands to a thickness of about three-quarters of an inch when the pressure is relieved.

2. As a new article of manufacture, a flat spring cushion pad of resilient wool having its fibers initially crushed down and set to a density approximating .01 pound or more per cubic inch.

3. A spring cushion for exposure to heat and steam, consisting of a pad or mat of dense but resilient metal wool, the individual fibers of the steel wool being coated with paraffin and having been set by compression substantially greater than 300 lbs. per square inch and substantially less than 5,000 lbs. per square inch.

Signed at Brooklyn, in the county of Kings and State of New York, this 10 day of June, A. D., 1929.

CROSBY FIELD.
CLINTON L. CAMPBELL.

APPENDIX C

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The changes in dimensions provide a criterion for the degree of compacting and bonding of the fibre web which can be attained. The extent of this change in dimensions depends on a great number of factors of varying degrees of significance. The basic feature is that cross orientated fibre web increases in length and decreases in width when needled. With few exceptions, shortening will occur when coarse fibre is needled with fine needles [87], although with short fibres there may be an increase in width [87].

The use of coarser needles, lower fibre web mass, greater puncture depth and density, finer and shorter fibre, normally results in greater change in longitudinal dimension and vice versa. It should be noted that the needle fineness has the greatest effect, a point that has been repeatedly made [67, 71, 82, 86, 87, 96]. Higher crimp and delustering of the fibre causes a slight increase in the dimensional change lengthwise [87].

The fineness and length of the fibre has far less effect on dimensional change widthwise than lengthwise. The same applies for the fineness of the needle [87], the puncture depth being a more important factor [71].

In this respect, it is necessary to consider the interaction of the various influencing factors. Numerous experiments have shown the considerable interaction between, for example, puncture and titre of the fibre [87], between the mass of the fibre web and the fibre length [87], and between needle thickness and titre of the fibre [67, 71], on the longitudinal measurements, and between needle thickness and puncture depth, and puncture depth and puncture density, on the cross direction [67, 71, 97].

Figures 2.80–2.85 illustrate the respective bulking density (pressure = 2 cN·cm^{-2}), the air permeability (test area = 20 cm^2, suppression = 2 mbar) and the maximum tensile load related to GSM and strip width for needled non-woven fabrics depending on important influencing factors. The figures given have been taken from a series of publications 67, 71, 86–88, 97, based on examination of cross orientated and partly lightly prestitched PA staple fibre web.

The thickness, GSM, bulking density and air permeability – which all provided information on the compactness of the needled fabric – are influenced by a number of factors. If finer needles, finer, longer and more tightly crimped fibres are used, if the GSM of the web and puncture depth and density are increased, the web density is greater and the air permeability is reduced (Figs. 2.80–2.85).

There is, however, an exception to this, for when finer fibres are needled with coarser needles, the web density does not increase (Fig. 2.80). There is neither an increase in web density nor a decrease in air permeability if the puncture density is increased (Fig. 2.85). In the latter case, there is interaction between the fineness of the needle and the puncture density.

As far as the strength of the needled non-woven fabric is concerned, the situation is similar to that for compactness, namely that finer needles, finer and longer fibre, greater GSM of the fibre web, and greater puncture depth and density, increase the strength (Figs. 2.80, 2.81, 2.83–2.85). It is also apparent, however, that once a certain 'critical' puncture depth or density has been reached, the rise in strength may be reversed and there may be a loss (Figs. 2.84 and 2.85).

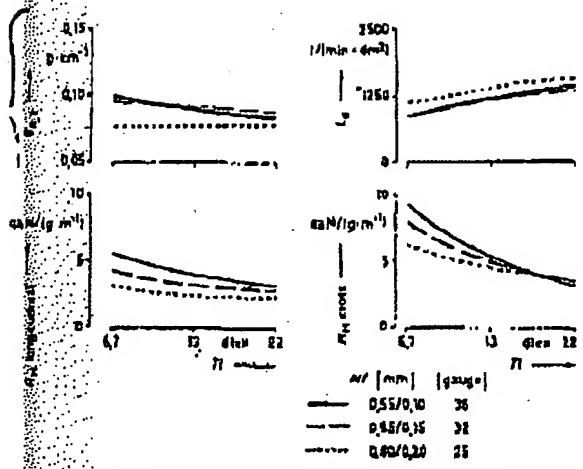

Fig. 2.80 — Web density $\varrho_{R,z}$ and air permeability L_d, also maximum tensile strength R_H related to GSM and strip width for longitudinal and cross directions dependent on titre of fibre T_t for different needle gauges Nf (RB needles, embossed) [71]. Puncture depth E_r = 11 mm, puncture density Ed_{Nf} = 240 cm^{-2}; number of runs N_{Pos} = 4; needle density N_d = 60 dm^{-2}; material feed in length L_v = 2.5 mm; fibre web, cross orientated, prenedled = 35 cm^{-2}; specified GSM $m_{A\,Pr}$ = 350 g·m^{-2}; PA-6 staple, semi-dull, fibre length = 80 mm, same finish.

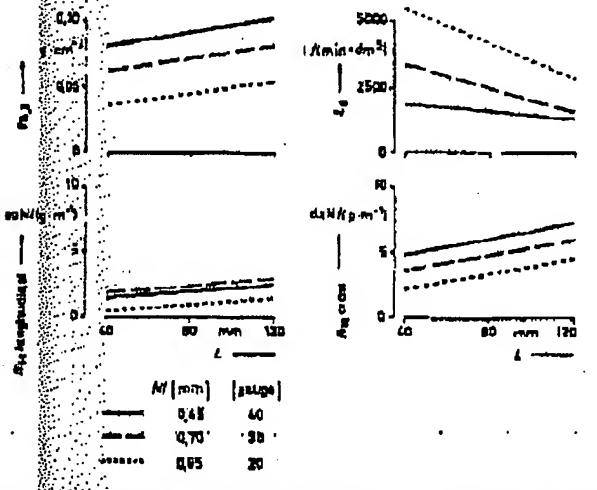

Fig. 2.81 — Web density $\varrho_{R,z}$ and air permeability L_d, also maximum tensile strength R_H related to GSM and strip width for longitudinal and cross directions, dependent on fibre length L for different needle gauges Nf (RB needles, embossed) [87]. Puncture depth E_r = 15 mm, puncture density Ed_{Nf} = 90 cm^{-2} fibre web, cross orientated, specified GSM $m_A \cdot P_r$ = 500 g·m^{-2}, PA-6 staple 11.3 dtex

APPENDIX D

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TEKRA

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DENSITY vs. SPECIFIC GRAVITY

***Density** (D)* -The mass (or weight) per unit volume of a material at a given temperature. Typical units are:

grams per cubic centimeter (g/cc or g/cm^3)
kilograms per cubic meter (kg/m^3)
pounds per cubic foot (lb/cu ft or lb/ft^3)
pounds per cubic inch (lb/cu in or lb/in^3)

***Specific Gravity** (sp gr)* - AKA relative density. The ratio of the density of a material at a given temperature to the density of an equal volume of water at the same temperature. Units = none.

Test reference: ASTM D 792, D 1505

Density and specific gravity are both ways of describing the weight (mass) of a certain quantity of material. They are useful in determining yield and comparing different materials.

SO WHAT'S THE DIFFERENCE?

NOT MUCH. The main difference is that density has units and specific gravity does not. Why not? Specific gravity is determined by dividing the density of a material by the density of an equal volume of water *using the same units*. The units therefore cancel each other out. This means you don't have to worry about conversions when comparing materials that have densities using different units.

The specific gravity value of any given material is going to be the same in the US, Germany or China!
(Also, materials with a specific gravity of less than 1 will float on water)

The down side is that without units you can't do anything but compare different materials. It's hard to determine, for instance, the weight of a **100** sheet stack of **24" x 48", 0.010"** polycarbonate. This is where density comes in handy. The density of polycarbonate is **0.0433 lb/cu in**. In the above example the stack weighs about 50 lbs.

100 x .010" x 24" x 48" = 1152 cu in x 0.0433 lb/cu in = 49.88 lbs.

Fortunately, there is a loophole in the "no units" rule for sp gr. It just so happens that the density of water in grams per cubic centimeter (g/cc) is very close to 1 (0.9976). This means that the *specific gravity of a material is virtually the same as its density in g/cc.*

Material density g/cc ÷ 1 g/cc = material density = specific gravity

Therefore, knowing the specific gravity and with the help of the handy conversion table on the shared drive one can determine the weight* of any given quantity of material in almost any units. Example:

What is the approximate weight (in pounds) of 3000 - 25" x 38" sheets of .010" press polished, clear RPVC?

Specific gravity = 1.35 (from data sheet)
Density = 1.35 g/cc (based on loophole)
Density = 0.0488 lb/cu in (from conversion table)
Volume of material = 28500 cu in (3000 x .010"x 25"x 38")
Weight = 1391 lb (28500 cu in x 0.0488 lb/cu in)

* The weight will vary slightly due to small variations in film thickness and sp gr.

Another option, of course, for those materials that we currently sell, would be to use the Yield Conversion program also on the shared drive.

Here's a list of densities of some common plastics:

Type of Plastic	sp gr[1]	Density[1] g/cc	Density[1] lb/cu in
ABS	1.04	1.04	0.0376
acrylic (polymethylmethacrylate - PMMA)	1.19	1.19	0.043
cellulose triacetate (CTA)	1.30	1.30	0.047
cellulose acetate butyrate (CAB)	1.21	1.21	0.0437
polyamide (Nylon 6)	1.13	1.13	0.0408
polyamide (Nylon 12)	1.02	1.02	0.0368
polycarbonate (PC) Makrofol	1.20	1.20	0.0433
polyethylene naphthalate (PEN) Kaladex	1.36	1.36	0.0491
PET polyester Melinex, Mylar	1.40	1.40	0.0506
polyetherimide (PEI)	1.27	1.27	0.0459
low density polyethylene (LDPE)	0.91	0.91	0.0329
high density polyethylene (HDPE)	0.95	0.95	0.0343
polyimide (PI) Kapton	1.42	1.42	0.0513
polypropylene cast (PP)	0.89	0.89	0.0322
polypropylene biaxially oriented (BOPP)	0.905	0.903	0.0326
polystyrene (PS)	1.05	1.05	0.0379
rigid vinyl (RPVC)	1.35	1.35	0.0488
flexible vinyl cast	1.22	1.22	0.0441
polyvinyl fluoride (PVF) Tedlar	1.44	1.44	0.0520

[1] These values are approximations for comparison purposes. They will vary based on grade of resin and additives such as pigments and fillers. For greater accuracy use the value from the data sheet or specification on actual product.